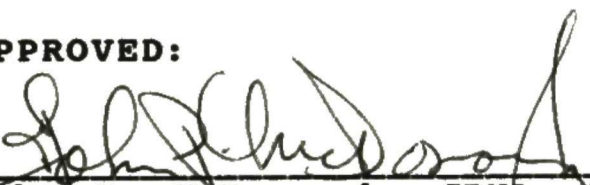# THE EFFECT OF INSPIRED OXYGEN CONCENTRATION AND TRANSPORTATION TIME ON ARTERIAL HEMOGLOBIN OXYGEN SATURATION DURING TRANSPORT FROM THE OPERATING ROOM TO THE POSTANESTHESIA CARE UNIT

1996

SWANAGIN

THE EFFECT OF INSPIRED OXYGEN CONCENTRATION

AND TRANSPORTATION TIME

ON ARTERIAL HEMOGLOBIN OXYGEN SATURATION

DURING TRANSPORT FROM THE OPERATING ROOM

TO THE POSTANESTHESIA CARE UNIT

Presented

by

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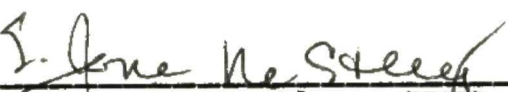
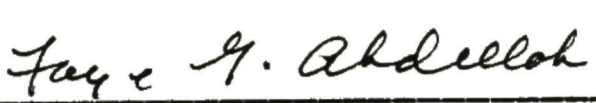beyond brief excerpts is with the permission of the copyright owner, and will save and hold harmless the Uniformed Services University of the Health Sciences from any damage which may arise from such copyright violations.

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Abstract

Early postoperative hypoxemia as a postanesthetic
complication often appears at the end of an operation and may
linger through the first postoperative hours. This hypoxemia is
often due to reduced functional residual capacity (FRC),
hypoventilation, and ventilation-perfusion mismatch. Early
postoperative hypoxemia leads to cellular ischemia which may delay
recovery or lead to organ dysfunction and increased morbidity and
mortality. In addition, posthyperventilation hypoventilation and
the persistence of ventilatory depression produced by anesthetics
and neuromuscular blocking drugs may aggravate hypoxemia. The
availability of pulse oximetry has made it possible to make
continuous measurements of arterial oxygen saturation (SaO_2)
intraoperatively and postoperatively. Oxygen saturation may
decrease during transport from the operating room to the
postanesthesia care unit (PACU). The purpose of this study was to
assess the degree of blood oxygenation during transport to the
PACU with and without supplemental oxygen. This study was
conducted using 40 adults, aged 16 to 79 years of age, who
underwent surgical procedures under general anesthesia. The
research study used a pretest-posttest control group design on a
convenience sample. Subjects were randomized into either the
treatment group or the control group. Those in the treatment group
received supplemental oxygen during transport to the PACU
postoperatively, while those in the control group did not.
Individuals in the control group who required supplemental oxygen
therapy during postoperative transport were eliminated. SaO_2 was

recorded just prior to transport to the PACU, transport time was recorded for each patient, and SaO_2 was recorded upon arrival in the PACU and as well as prior to the institution of supplemental oxygen, unless already being used. Results showed no difference between groups in age, body weight, smoking history, baseline hemoglobin, baseline SaO_2, surgery time, and transport time. There were no statistically significant differences in pretransport and post-transport SaO_2's. Transport time had no significant impact on the post-transport SaO_2 in either group. There was no significance noted in the post-transport SaO_2 of those patients who had abdominal or thoracic incisions. Breathing supplemental oxygen versus room air had no significant impact on post-transport SaO_2's. SaO_2 did not decrease significantly with an increase in transport time in the group without supplemental oxygen. Routine use of supplemental oxygen during postoperative transport to the PACU may be unwarranted where OR suite to PACU transport times are less than one minute. Similar studies should focus on transport times that exceed one minute such as PACUs and surgical intensive care units which are at great distances from the OR suite.

TABLE OF CONTENTS

Chapter One

Introduction

Background of the Problem

It has been well documented that arterial oxygen desaturation develops in the early postoperative period and lasts for several hours if not days (Graham, Chang, & Steven, 1986). This postoperative desaturation may be due to diffusion hypoxia which can occur during the first 10 minutes after anesthesia with nitrous oxide if the patient is given a low or room air inspired oxygen fraction. This is due to re-equilibration of nitrous oxide in the bloodstream into the alveolus after the nitrous oxide is discontinued. This dilutes the inspired oxygen and nitrogen, causing a lower concentration of both gases, which can cause a transient hypoxemia. If nitrogen was a more soluble gas (nitrous oxide is 31 times more soluble than nitrogen) in blood than nitrous oxide, this would not occur due to rapid equilibration of nitrogen in the bloodstream and maintenance of a reasonable inspired oxygen fraction in the immediate postoperative period (Pesola & Kvetan, 1990).

It is common in most recovery rooms to administer supplemental oxygen in the immediate postoperative period because of the high incidence of hypoxia in patients in this setting (Graham, et al., 1986). Whether or not to use supplemental oxygen when transporting patients to the PAR from the operating room (OR) is less clear since little data are available. The need for postoperative oxygen therapy after surgery involving an incision to the thorax or upper

abdomen is well known (Gift, Stanik, Karpenick, Whitmore, & Bolgiano, 1995). Canet, Ricos, & Vidal (1989) found that oxygen saturation increased in patients who had a peripheral site for surgery while they breathed room air during their first 10 minutes in the postoperative anesthesia care unit (PACU) (Canet, et al., 1989). Thus the need for oxygen therapy in those having surgery to the face, neck, lower abdomen, or extremities, is open to question, especially in the present environment of cost containment (Gift, et al., 1995).

In the absence of an adequate noninvasive monitoring device, it was considered wise practice in the past to administer oxygen therapy to all postoperative patients. Pulse oximetry is now a standard of care in surgery and the immediate postoperative period. It allows the noninvasive monitoring of oxygen saturation to indicate the need for oxygen therapy (Gift, et al., 1995). According to Gift (1995),

> "the routine use of oxygen therapy in patients at low risk for hypoxemia who have adequate oxygen saturation may be an unwarranted expense. Clinical practice for use of oxygen varies among institutions; some require oxygen therapy for this group of patients and others do not" (p. 368).

Jacobsen, Nielsen, Brinklov, Stokke, & Hartmann-Anderson (1980) state that impairment of arterial oxygenation in the period after the operation is a common occurrence even in young patients without pre-existing respiratory or

cardiovascular disease. Even patients with a normal $PaCO_2$, cardiac output, and pulmonary function may experience some degree of arterial hypoxemia after general anesthesia of as little as 10 minutes in duration (Jacobsen, et al.,1980).

It is not cost effective in this time of diminishing resources to use oxygen-enhancing therapy to increase the oxygen saturation from one normal level to another. There is a ceiling effect for the therapy as SaO_2 achieves 100% (Gift, et al., 1995). That is, increasing the SaO_2 from 95% to 100% by providing supplemental O_2 is not physiologically necessary or of any benefit. Pulse oximetry now available can determine those at most risk for hypoxemia and oxygen can be administered only to those who need it.

"The reduced risk of iatrogenic morbidity
and mortality may be worth the cost and incon-
venience of using an oxygen tank and mask for
transport from the OR to the PACU"
(Hoffman, Nakamoto, Okal, & Clochesy, 1991)

Rationale and Significance of the Problem

The indiscriminate use of supplemental oxygen for all patients in the postanesthesia care unit (PACU) and during the time of transport from the OR has been challenged (DiBenedetto, Graves, Gravenstein, & Konicek, 1994). In their study of 307 postoperative patients who had not

received oxygen, they showed a savings to those patients of $31,928, and a potential annual savings of $623,272. They suggested that supplemental oxygen only be used when a need is demonstrated. Graham (1986), on the contrary, believed that "consideration should be given to routine oxygen administration during transit from the OR to the PAR, especially in the elderly patient and if the transport time is not assuredly brief". It must be noted, however, that Graham's study was done during the time when the availability of pulse oximetry was less than it is today.

Consideration must be given not only to the use and types of supplemental oxygen delivery systems used during the transport period to the PACU, but also to the transport time itself. Canet, et al. (1989) found significant differences in oxygen saturation when administering 35% oxygen to adults in the PACU after a 30-second transport while breathing room air. "Patients may experience transport times longer than 240 seconds depending on the distance between individual operating rooms and the PACU (Hoffman, Nakamoto, Okal, and Clochesy, 1991). "Transport frequently occurs in an uncontrolled environment without oxygen and resuscitation equipment immediately available" (Hoffman, et al., 1991). Although it has been considered that early hypoxemia lasts about two hours after the surgical procedure, the first 20 minutes of the postoperative period seem to be most critical (Canet, et al., 1989). It would seem that the majority of transport times would fall within this 20 minute window, thus the increased potential for postoperative hypoxemia during

the transport period.

Ambulatory patients are less likely to have the risk factors such as abdominal or thoracic incisions, obesity, respiratory disease, or increased age that predispose surgical inpatients breathing room air to hypoxemia (Diament & Palmer, 1966; Drummond & Milne, 1977; Marshall & Millar, 1965; Kitamura, Sawa, & Ikezon, 1972). Thus routine supplemental oxygen may not be necessary after ambulatory surgery (Murray, Raemer, & Morris, 1988).

Patient safety must remain the primary focus of the anesthesia care team. No one disputes the fact that early postoperative hypoxemia does occur (Hoffman, et al., 1991). Consequently, more scientific studies are needed to identify those patients who have the greatest risk for developing postoperative hypoxemia as well as treatment strategies to reduce morbidity and mortality in those patients.

Statement of the Problem

The purpose of this study was to determine if a statistically significant difference existed between transport time and arterial hemoglobin oxygen saturation in patients breathing room air versus supplemental oxygen during transport from the operating room (OR) to the postanesthesia care unit (PACU).

Another purpose of this study was to determine if there was a statistically significant difference in SaO_2 measured upon arrival in the PACU in patients who have been given

supplemental O_2 versus those who were not given supplemental O_2 during transport.

General Hypotheses

The two null hypotheses are:

1) No difference exists in arterial hemoglobin oxygen saturation levels on admission to the PACU in patients who breathe room air as compared to patients who receive supplemental oxygen during transport from the OR to the PACU.

2) Transport time from the OR to the PACU has no impact on SaO_2 levels on admission to the PACU in patients who breathe room air as compared to patients who receive supplemental oxygen during transport from the OR to the PACU.

Definition of Terms

Pre-transport SaO_2- The arterial hemoglobin oxygen saturation level as measured immediately prior to transport from the OR to the PACU.

Post-transport SaO_2- The arterial hemoglobin oxygen saturation level as measured immediately upon arrival in the PACU from the OR.

Transport time- The time as recorded from leaving the OR postoperatively until arrival in the PACU.

Supplemental oxygen- Oxygen administered either by nasal cannula or face mask.

Treatment group- Patients who received supplemental oxygen

during transport from the OR to the PACU.

Control group- Patients who breathed room air during

transport from the OR to the PACU.

Summary and Overview

The majority of previous studies have focused on those patients that would seem most likely to develop postoperative hypoxemia, rather than "healthy" patients. Two studies were done involving American Society of Anesthesiologist (ASA) Class I and II patients. The first involved 164 healthy adults. The researchers concluded that brief periods of moderate hypoxemia may not be harmful to healthy people, who would consequently, not require supplemental oxygen (Murray, et al., 1988). They did point out that moderate hypoxemia may precede the occasional severe episode. Their recommendation was to provide supplemental oxygen to all ambulatory patients recovering from general anesthesia. The second study involved 71 healthy pediatric patients undergoing general anesthesia. Clinically significant arterial desaturation ($SaO_2 \leq 90\%$), occurred in 28.1 percent of their study population who were breathing room air during the transfer from the operating room to the postanesthesia care unit (Pullerits, Burrows, & Roy, 1987).

This study focused on ASA Class I, II, and III patients receiving surgical procedures under general anesthesia, and included ambulatory surgery, as well as inpatient surgery patients.

Chapter Two

Review of the Literature

"Since the early work of McClure et al. nearly 50 years ago, hemoglobin-oxygen desaturation has been established as a complication of general anesthesia, spinal anesthesia, and sedation with opioid and hypnotic drugs" (Kurth, 1995). Subsequent research into the pathogenesis of perioperative desaturation and technologic advances in the detection of arterial desaturation combined to play a substantial role in improving anesthesia safety to its current levels (Kurth, 1995). During this decade, economics motivates research into the nature of perioperative desaturation as well as safety. (Kurth, 1995). Arterial desaturation may increase cost by the need for additional therapy, higher acuity of care, or longer hospitalization.

As recently as 1985 it was reported that "there is a surprising lack of data on patient oxygenation during postoperative transfer, explainable in part by the difficulty of measuring blood gases under such conditions" (Tyler, Tantisira, Winter, & Motoyama, 1985). Just two years prior, Yelderman and New (1983) found the pulse oximeter linearly accurate and precise over the range of 70 - 100% in noninvasive measurement of arterial hemoglobin oxygen saturation. This heralded the beginnings of pulse oximetry for the measurement of oxygen saturation during and after surgery.

Oxygen hemoglobin saturation during the early period of

anesthetic recovery, however, has not been extensively and continuously measured using pulse oximetry (Canet, Ricos, & Vidal, 1989). Although routine administration of oxygen during the postoperative period is widely accepted, the benefit of this therapy, quantitated in terms of changes in SaO_2, has not been reported (Canet, et al., 1989). Graham, Chang, & Stevens (1986) recommend supplemental oxygen for all patients during transport between the operating room and the post-anesthesia recovery room to prevent hypoxemia. Although the nasal cannula and simple face mask are the devices most often used in providing supplemental oxygen, "research has neither demonstrated nor compared their effectiveness in preventing hypoxemia during the transport period" (Adamson & Janken, 1992). Studies have been done, however, demonstrating the effectiveness of these devices in the post-anesthesia care unit (Adamson & Janken, 1992). This study examined the relationship between supplemental oxygen, or the lack of same, and arterial hemoglobin oxygen saturation in the immediate postoperative period and upon arrival in the postanesthesia care unit. They found subjects in the simple mask group attained and maintained higher mean SaO_2 values over the transport period than did those in the nasal cannula group. In addition, the mean SaO_2 at the end of the transport period for the simple face mask group was significantly higher than the mean for the cannula group.

Conceptual Framework

The theoretical base for this research was the Roy adaptation model (Galbreath, 1985). The most basic premise of the Roy model is that the patient or individual is considered an adaptive system. The individual is considered a system because people are in constant interaction with their environments, thus exchanging information, matter, and energy. Adaptation occurs as a result of this interaction as well as the individuals' efforts to maintain integrity. These interactions are characterized by internal and external change (Galbreath, 1985). An individual who has undergone any type of surgery under general anesthesia has certainly experienced some degree of challenge to their adaptive system.

Summary

Little research has been conducted on postoperative hypoxemia during transport to the postanesthesia care unit. Because postoperative hypoxemia is a common occurrence in patients after general anesthesia breathing room air (Murray, Raemer, & Morris, 1988), it would behoove our profession to take the lead in researching this phenomenon.

Chapter Three

Methodology

This study used descriptive (quantitative) research methods. Data relating to the descriptive portion of the study were obtained by recording transport times and arterial hemoglobin oxygen saturation levels.

Introduction

This study was conducted at a 350 bed community hospital in a northeastern city. The anesthesia department supports 8,000 cases a year. Of the total number of cases, 40% were general anesthesia, 40% were monitored anesthesia care (MAC), and 20% were regional anesthesia. The anesthesia department had five anesthesiologists and nine Certified Registered Nurse Anesthetists (CRNA). No anesthesiology resident physicians trained at this facility.

Design of the Study

A pretest-posttest control group design was used to study the effect of oxygen delivery during transport from the operating room to the postanesthesia care unit. Subjects were alternately assigned to either the treatment or the control group.

Sample

There was a convenience sample of 40 adults aged 16 to
79 having ambulatory or inpatient surgical procedures under
general anesthesia. Approval by the Institutional Review
Board was obtained. After giving informed consent, subjects
participated in the study if they met the following criteria:

1. not involved in another research project;

2. did not require preoperative supplemental oxygen;

3. ASA classification I, II, and III;

4. 16 to 80 years of age;

5. abstinence from tobacco smoking for at least 12
   hours prior to surgery;

6. undergoing surgical procedure with general
   anesthesia;

7. free from cardiopulmonary complications during
   anesthesia; and

8. successfully extubated in the operating room.

Instrumentation

A pulse oximeter was used to noninvasively assess
arterial hemoglobin oxygen saturation (SaO_2). Pulse oximetry
accurately measures SaO_2 in the range of 65% to 100% (Mihm &
Halperin, 1985). The SaO_2 may, however, be falsely elevated
in smokers unless they have abstained from smoking for over
12 hours because the oximeter fails to distinguish between

oxyhemoglobin and carboxyhemoglobin (Patel, Norden, & Hannallah, 1988). Transport time was measured using a single event stopwatch.

Procedure

Permission was obtained from the participating facility prior to the gathering of data. Patients were not identified by name, thereby maintaining strict confidentiality. The first forty patients to meet the eight criteria were included in the study. A patient consent form was obtained for each patient prior to inclusion in the study. (See Appendix B)

All forty patients were moved to a stretcher from the operating room bed after extubation in preparation for transport to the PACU. The head of the bed was consistently elevated to 30 degrees for each patient after being moved to the stretcher. Patients in the treatment group received supplemental oxygen either by nasal cannula or simple face mask, with corresponding FIO_2's of 28% to 60%. Patients in the control group breathed room air with an FIO_2 of 21%. All study patients' SaO_2's were measured immediately before transport to the PACU and again upon arrival in the PACU. FIO_2's varied from patient to patient in the treatment group, according to patient needs.

Data Collection

The following information was recorded for each patient in the study on the data collection form (See Appendix A):

1. Age (y)
2. Weight (kg)
3. Smoking (pk-y)
4. Hemoglobin (g/l)
5. Baseline SaO_2/temp
6. Sex
7. ASA status
8. Anesthetic agent
9. Narcotic
10. Incision site
11. Estimated blood loss
12. Surgical time
13. Transport time
14. Pre-transport SaO_2
15. Post-transport SaO_2
16. O_2 used during transport

Data Analysis

Descriptive statistic were used to describe demographics. The unpaired t test was used to compare subject characteristics between the two groups. A Pearson's R test was used to evaluate the relationship between the length of transport time and post-transport SaO_2. Two-tailed, unpaired t tests were used to compare pre-transport SaO_2 and post-transport SaO_2 between the treatment and control groups. Analysis of data was performed using SPSS/PC+ version 6.0 (SPSS Inc., Chicago, IL), BMDP version 1992 (BMDP Statistical Software, Los Angeles, CA). For statistical significance the alpha was set at .05(%). Subject characteristics of age, weight, smoking history, preoperative hemoglobin, baseline

SaO$_2$, estimated blood loss, surgery time, transport time, pre-transport SaO$_2$, and post-transport SaO$_2$ were compared and analyzed using the t-test for independent samples and Levene's Test for Equality of Variances (Tables 1 and 3). The subject characteristics of sex, ASA status, and incision site were listed by frequency (Table 2). An analysis of variance test was used to evaluate the relationship between the postoperative arterial hemoglobin saturation levels and transport times between the treatment and control groups.

Limitations

Several limitations of the study were: (1) SaO$_2$ measurements done in the OR and PACU were done on different brands of pulse oximetry machine (2) pulse oximetry readings were not done continuously, as in Biddle's study, and (3) clear, specific criteria for discharge from the OR postoperatively were not incorporated into the study.

An even more important limitation may have been the lack of specific guidelines on the exact FIO$_2$ to use for patients in the treatment group, i.e. 28% by nasal cannula or 40% by simple face mask, for example.

Chapter Five

Results

Hypotheses

It was hypothesized that: There is no statistically significant difference in arterial hemoglobin oxygen saturation levels on admission to the PACU in patients who breathe room air as compared to patients who receive supplemental oxygen during transport from the OR to the PACU.

No statistically significant difference in arterial hemoglobin oxygen saturation levels were found on admission to the PACU in patients who breathe room air as compared to patients who receive supplemental oxygen during transport from the OR to the PACU.

The mean postoperative arterial hemoglobin saturation levels were 99.15% for the treatment group (range 98.2-100%) and 99.05% for the control group (range 98.2-100%) with a probability level (p) of 0.088 by Levene's test for equality of variances. The two-tailed significance levels between treatment and control groups were 0.816 and 0.817 consecutively, using the t-test for equality of means and using a significance level of .05. These results support the null hypothesis.

It was hypothesized that: Transport time from the OR to the PACU has no statistically significant impact on arterial hemoglobin oxygen saturation levels on admission to the PACU in patients who breathe room air as compared to patients who

receive supplemental oxygen during transport from the OR to the PACU.

Transport time from the OR to the PACU has no statistically significant impact on arterial hemoglobin oxygen saturation levels on admission to the PACU in patients who breathe room air as compared to patients who receive supplemental oxygen during transport from the OR to the PACU.

An analysis of variance test was used to evaluate the relationship between the postoperative arterial hemoglobin saturation levels and transport times between the treatment and control groups. A unique sums of squares showed a significance of F value of .497 (significance level of .05). The mean transport time for the treatment group was 51 seconds, versus 52 seconds for the control group with a probability level of .841 by Levene's test of equality of variances. *T*-tests for independent samples found the two-tailed significance level between treatment and control groups was .925 (significance level of .05). These results support the null hypothesis.

Additional Data Analysis

There were no statistically significant differences in subject characteristics between groups regarding age, weight, smoking history, hemoglobin, and baseline SaO_2 values (see Table 1).

Table 1

<u>Subject Characteristics by Group (Mean +/- SE)</u>

	Control Group (n = 20)	Treatment Group (n = 20)	t value	p value
Age (y)	44.7 ± 13.6	48.6 ± 14.1	0.90	0.70
Weight (kg)	78.0 ± 19.3	81.4 ± 17.7	0.58	0.90
Smoking (pk-y)	6.5 ± 10.0	8.7 ± 15.0	0.53	0.15
Hemoglobin (g/L)	12.8 ± 1.7	12.4 ± 2.1	0.62	0.23
Preop SaO_2 (%)	96.9 ± 1.8	96.9 ± 1.9	0.00	0.64

<u>p</u><.05 (significance level)
df=38
Critical value for t-statistic = 2.01
*No t-values are greater than 2.01, nor p-values less than .05, therefore no statistically significant data exist between groups regarding these characteristics.

Subject characteristics between groups were listed. These characteristics were the patients' sex, ASA status, and incision sites (see Table 2).

Table 2

Subject Characteristics According to Group (Frequency)

	Control Group (n = 20)	Treatment Group (n = 20)
Sex		
Male	5	8
Female	15	12
ASA Status		
I	4	0
II	10	8
III	6	12
Incision Site		
Perineum	1	1
Extremity	10	5
Back	0	0
Abdomen	4	6
Thorax	1	6
Head	4	2

There were no statistically significant differences between groups comparing estimated blood loss (EBL), surgical time, transport time, immediate postoperative SaO_2 as measured upon arrival in the postanesthesia care unit (SaO_2 #2) (See Table 3).

Table 3

Intraoperative and Postoperative Data by Group (Mean +/- SD)

	Control Group (n = 20)	Treatment Group (n = 20)	t value	p value
EBL (ml)	30.0 ± 80.1	220 ± 414.7	2.01*	.00**
Surg Time (mins)	105.5 ± 53.1	127 ± 81.5	.33	.07
Trans Time (mins)	51.8 ± 20.9	51.2 ± 22.7	− .09	.84
SaO_2 (%) OR	98.7 ± 1.2	98.6 ± 1.1	− .41	.77
SaO_2 (%) PACU	99.0 ± 1.6	99.1 ± .9	.23	.08

p < .05 (significance level)
df = 38
Critical value for t-statistic = 2.01
t-value (*) was equal to critical value for estimated blood
loss (EBL) and p-value was less than .05 significance level,
therefore statisitical significance existed between groups
regarding this characteristic.

Summary

Hypotheses Tested - significance level .05

1) There is no statistically significant difference in SaO_2 on admission to the PACU between patients who receive supplemental oxygen during transport from the OR to the PACU and those who do not.

Null hypothesis supported

2) Transport time from the OR to the PACU has no statistically significant impact on SaO_2 levels on admission to the PACU in patients who breathe room air as compared to patients who receive supplemental oxygen during transport from the OR to the PACU.

Null hypothesis supported

Group characteristics of age, weight, smoking history, baseline hemoglobin, baseline SaO_2, estimated blood loss, surgery time, and transport time were analyzed. Significance was found between the treatment and control groups regarding estimated blood loss with a p value of 0.00 (.05 significance level). The mean estimated blood loss for the control group was 30 milliliters and 220 milliliters for the treatment group.

Most notably, transport time nor supplemental oxygen administration had a significant impact on the patients' arterial oxygen saturation levels as measured immediately upon arrival in the PACU (post-transport SaO_2).

Chapter Five

Discussion

Overview of Study

It has been well documented that hemoglobin desaturation develops in the early postoperative period and lasts for several hours if not days. It is common in most recovery rooms to administer supplemental oxygen in the immediate postoperative period because of the high incidence of hypoxemia that occurs during this time. Whether or not to use supplemental oxygen when transporting patients to the PACU from the operating room (OR) is less clear since little data are available.

Healthy patients frequently breathe room air during transfer from the operating room to the postanesthesia care unit when ventilation is likely to be depressed from residual inhalation anesthetics, narcotics, or muscle relaxants (Tyler, Tantisira, Winter, & Motoyama, 1985). Equilibration of SaO_2 with inspired gas mixtures takes approximately 30 seconds in normal volunteers, and patient transfer from the OR to the PACU may take several minutes. Thus, the administration of 100% oxygen, even to a patient with a normal minute ventilation, does not guarantee normal SaO_2 during transfer while breathing room air if there is an excessive alveolar-arterial oxygen gradient (A-aDO_2) (Tyler, et al., 1985).

The need for increased inspired oxygen therapy after surgery involving an incision to the thorax or upper abdomen

is well known (Tyler, et al., 1985). The need for oxygen therapy in those having surgery to the face, neck, lower abdomen, or extremities, is open to question. A study by Canet, et al., 1989 showed satisfactory SaO_2 while breathing room air postoperaively in these types of patients. This study used patients having incisions of either the perineum, extremity, abdomen, thorax, or head, to identify whether or not breathing supplemental oxygen versus room air had a significant impact on SaO_2 immediately upon arrival in the PACU postoperatively.

This study used ambulatory surgery and inpatient surgery patients which may be a limiting factor in this study. Ambulatory patients are less likely to have the risk factors (abdominal or thoracic incisions, obesity, respiratory disease, or increased age) and have a lower prevalence of postoperative hypoxemia. Thus, routine supplemental oxygen may not be necessary after ambulatory surgery. (Murray, Raemer, & Morris, 1988).

Biddle, et al., (1987) examined 60 physically fit surgical patients to determine whether adequate oxygenation could be maintained postoperatively simply through positioning and deep breahing alone. The ASA classifications, types of surgery, and ages of the patients in Biddle's study were very similar to this study. They found significantly higher SaO_2's in those patients who were positioned in a semirecumbent position with the head of the bed elevated 40 degrees and who were coached to deep breathe every 10 to 15 seconds. Also, as with Biddle's study, patients were

encouraged to deep breathe and each patient's head of the bed was raised approximately 30 degrees.

The ages of the participants in the study ranged from 16 to 79 years. Murray, et al.(1988) showed the decrease in SaO_2 below preoperative levels 1-2 hours postoperatively to be greater in older patients. They also found general anesthesia causes a greater reduction in functional residual capacity (FRC) and increased ventilation-perfusion inequality with increased age (Murray, et al., 1988). True shunt increases in patients postoperatively, regardless of age, and the effect of ventilation-perfusion abnormality becomes increasingly apparent postoperatively with advancing age (Kitamura, Sawa, & Ikezono, 1972).

The patients in this study were chosen based on two criteria: (1) surgery requiring general endotracheal anesthesia and (2) classification according to the ASA physical status categorization as either I, II, or III. Patients requiring general endotracheal anesthesia were chosen because of the research on respiratory and physiologic changes that occur during and after general anesthesia. These changes cause postoperative desaturation of SaO_2 in adults because of abnormal gas exchange in the lung (atelectasis) and an abnormal control of breathing (obstructive apnea) (Kurth, 1995). According to McCarthy (1987) general anesthesia causes increased ventilation-perfusion mismatch by decreasing functional residual capacity, increasing airway closure, decreasing pulmonary artery pressure, increased alveolar pressure, and decreased

hypoxic pulmonary vasoconstrictive reflex.

Several limitations of the study were: (1) SaO_2 measurements done in the OR and PACU were done on different brands of pulse oximetry machine (2) pulse oximetry readings were not done continuouslyor consistently using the same model pulse oximeter, as in Biddle's study, and (3) clear, specific criteria for discharge from the OR postoperatively were not incorportated into the study.

An even more important limitation may have been the lack of specific guidelines on the exact FIO_2 to use for patients in the treatment group, i.e. 28% by nasal cannula or 40% by simple face mask, for example.

Overview of Results

1. No statistically significant difference in SaO_2 on admission to the PACU in patients who breathed room air as compared to patients who received supplemental oxygen during transport from the OR to PACU.

2. Transport time from the OR to the PACU had no statistically significant impact on SaO_2 on admission to the PACU in patients who breathed room air as compared to patients who received supplemental oxygen during transport from the OR to the PACU.

3. There was a statistically significant difference in the EBL mean between groups (.05 significance level). The mean for the treatment group was 220 milliliters compared to the mean of 30 milliliters for the control group.

4. There was no statistically significant difference between groups regarding post-transport SaO$_2$. It must be noted that it is routine practice at this facility to ensure high SaO$_2$'s prior to transport from the operating room, e.g. 97 to 100%, a point that could have dramatically changed the first measured SaO$_2$'s in the PACU.

Results of this study indicate that the routine use of supplemental oxygen postoperatively may be an unwarranted expense for patients. Factors were analyzed which have been shown to have a negative affect on postoperative SaO$_2$. These include weight, smoking history, age, and length of surgery. Because no statistically significant differences were shown regarding these factors between groups, no inference can be made on their impact on each group's post-transport SaO$_2$ values.

Transport time was one of the primary variables analyzed. The mean transport time for the group given supplemental O$_2$ (FIO$_2$ 28-60%) was 51 seconds. Transport time had no adverse effect on post-transport SaO$_2$ in either group. This study's findings support those of Gift, et al.(1995) which suggest, because of the noninvasive technology now available to determine those at risk for hypoxemia, administering oxygen therapy only to those who need it.

Although there was a statistically significant difference for ASA classification and estimated blood loss between groups there was no significant effect on post-transport SaO$_2$.

Implications of Results in terms of Theory

Because of what we know today about general anesthesia and its effects on the respiratory system, it would seem paramount that the anesthesia community agree on how we approach this postoperative oxygenation dilemma. Should supplemental oxygen be given to all postoperative patients or only to particular patients? Or should supplemental oxygen be provided on a case by case basis? Clinical experience shows that certain patients have an increased susceptability for developing postoperative hypoxemia. Other patients will generally do quite well, regardless of our aggressive endeavors to achieve the "ideal" SaO_2. This study supports Sister Callista Roy's theory that patients be treated as individuals, maintaining flexibility and adaptability toward their particular needs.

Implications of Results in terms of Research

The small number of subjects in this study indicates the need for replication in larger populations. Studying a larger population may show more significance between groups regarding characteristics such as age, sex, ASA classification, weight, and smoking history. Caution must be used in interpreting the results of this study because of the low power of the study due to the small n (sample size=40). Perhaps individual characteristics should be scrutinized more scientifcally. Questions such as: "Do morbidly obese

patients always have lower postoperative oxygen saturation levels than non-obese patients of similar ASA classification?" or "Do ASA II patients always need supplemental oxygen in transport postoperatively?"

Because the proximity of the operating room complex to the postanesthesia care unit (PACU) was extremely close suggests that research be done in those facilities where transport times can be lengthy, with the PACU far removed from the OR.

Implications of Results in terms of Practice

In the absence of an adequate noninvasive monitoring device, it was considered wise practice in the past to administer oxygen therapy to all postoperative patients. Pulse oximetry is now a standard of care in surgery and the immediate postoperative period. It allows the noninvasive monitoring of oxygen saturation to indicate the need for oxygen therapy (Gift, et al., 1995). Because the anesthesia community now has incorporated this invaluable tool as a standard of care, it becomes increasingly important that SaO_2 be monitored continuously and closely because it can often alert the anesthesia provider of hypoxemia early.

Anesthesia providers have responsibility for each patient's safety and well being during the immediate postoperative period. Efforts must continue to focus on ways to ensure this safety through research on oxygenation and oxygen delivery systems during this critical time.

Summary

A plethora of information exists addressing oxygen delivery systems, postoperative pulmonary complications, and patient characteristics that frequently lend themselves to postoperative pulmonary complications. These major topics of discussion must be taken into consideration when addressing concerns about a patient's oxygenation status after they have been extubated and just prior to arrival in the postanesthesia care unit.

This study evaluated whether supplemental oxygen versus room air, as well as transport time, had a significant impact on postoperative SaO_2. Results showed that no statistically significant difference existed between those that did receive supplemental oxygen as compared to those who did not. Likewise, transport time, at least in this study, played no role in altering postoperative saturation levels. Again, caution must be taken in forming any conclusions from the results of this study due to its relatively small n and low power.

Although ambulatory surgery and inpatients were used, it could be postulated that this may be the future of anesthesia settings. Ambulatory surgery is becoming securely entrenched in our health care system, and at the same time, hospitals are downsizing.

Patients are being operated on sooner and leaving the hospital earlier as a direct result of Diagnosis Related Groups and cost containment. Anesthesia providers must become more vigilant during that period when the patient is often

most vulnerable to complications, the transfer from the operating room to the postanesthesia care unit.

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Appendix A

Data Collection Form

1. Age _____Study Subject#____Patient ID#_____

2. Weight (kg) _____

3. Smoking (pk-y) _____

4. Hemoglobin (g/L) _____

5. Baseline SpO_2/temperature _____

6. Sex
    Male/Female _____

7. ASA Status (I, II, III) _____

8. Anesthetic Agent
    Enflurane _____

    Halothane _____

    Desflurane _____

    Isoflurane _____

    Nitrous oxide _____

    Propofol _____

9. Narcotic (total mg's)
    Alfentanil _____

    Sufentanil _____

    Fentanyl _____

    Morphine _____

    None _____

10. Incision Site
    Perineum _____

    Extremity _____

    Back _____

    Abdomen _____

    Thorax _____

    Head _____

11. EBL (Estimated Blood Loss) _____

12. Surgical Time _____

13. Transport Time _____

14. SpO_2 #1 _____

15. SpO_2 #2 _____

16. Oxygen used during transport?   YES   NO

Appendix B
Oxygen Saturation Consent Form

This oxygen saturation consent form is presented to

_____ for participation in the
POST-OPERATIVE OXYGEN SATURATION STUDY. This study examines the
effects of the inspired concentration of oxygen and transport time
on arterial oxygen saturation during transport from the operating
room to the postanesthesia care unit.

   The following information will be obtained:
   1.   Age
   2.   Weight
   3.   Smoking history
   4.   Preoperative hemoglobin
   5.   Baseline arterial oxygen saturation
   6.   Gender
   7.   American Society of Anesthesiologist Classification
   8.   Anesthetic agent used intraoperatively
   9.   Narcotic used intraoperatively
   10. Incision site
   11. Estimated blood loss intraoperatively
   12. Length of surgery
   13. Length of transport time from operating room to recovery
        room
   14. Arterial oxygen saturation levels immediately postop
        and upon arrival in the postanesthesia care unit
   15. Whether oxygen was used during the transport period
        postoperatively

   All information will be kept strictly confidential.
   Subjects will have their arterial oxygen saturation levels
measured by pulse oximetry immediately after surgery and upon
arrival in the postanesthesia care unit. The amount of time
required for transport, in seconds, from the operating room to the
postanesthesia care unit will also be recorded.
   GROUP A will receive supplemental oxygen postoperatively,

during transport from the operating room to the postanesthesia care unit as directed by the anesthesia care provider.

GROUP B will be transported to the postanesthesia care unit on room air as directed by the anesthesia care provider.

This study is being conducted by STEPHEN E. SWANAGIN, MSN, SRNA, at Greater Southeast Community Hospital under the supervision of DR. JOHN P. McDONOUGH, CRNA EdD. Questions regarding this study may be directed to either of these persons at the Greater Southeast Community Hospital Anesthesia Department.

Participation is strictly voluntary, and subjects may withdraw at any time without jeopardizing their present or future medical care. There will be no additional cost to the subject, and no financial compensation will be given.

All subjects participating in this study will receive the usual and customary procedures for the administration of anesthesia and postoperative oxygen administration.

POTENTIAL RISKS: There are no additional risks to patients beyond those normally incurred during the course of anesthesia care. The undersigned acknowledges that he/she has previously been informed of the risks of anesthesia.

I HAVE READ THE ABOVE CONSENT FORM AND HAVE HAD AN OPPORTUNITY TO ASK ANY QUESTIONS. I HAVE BEEN INFORMED OF THE RISKS OF ANESTHESIA. I AGREE TO PARTICIPATE IN THE STUDY AS DESCRIBED ABOVE. I UNDERSTAND THE MEANING OF PULSE OXIMETRY. I UNDERSTAND I WILL BE ASSIGNED TO GROUP _____.

_____   _____
(Date)   (Signature of patient)

_____   _____
(Date)   (Signature of Investigator)

_____   _____
(Date)   (Signature of Witness)